SmaggIce User Guide

SmaggIce Version 1.2

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CHAPTER 1

Introduction

What is SmaggIce?

SmaggIce (Surface Modeling And Grid Generation for Iced Airfoils) is an interactive computer code for icing effects study on 2-dimensional (2D) airfoils. It is being developed at the NASA Glenn Research Center and is being released in phases. When fully completed (see future release feature list below), it will be a software toolkit that will streamline the 2D icing aero analysis process from geometry modeling, to grid generation, to flow simulation.

SmaggIce version 1.2 is currently available for release and provides tools for:

- measuring ice shape characteristics such as ice horn height, angle, location, and ice area
- creating and placing computer-generated ice shapes for ice roughness and parametric study
- examining and preparing ice shape data for grid generation for icing aerodynamic simulations

Future releases will include the following additional features:

- domain decomposition
- block boundary discretization
- block modification (e.g. divide block, merge blocks, etc.)
- grid generation and modification
- grid quality check and control
- output files in emerging standard CGNS format
- linking with the flow solver WIND

Release Information

SmaggIce version 1.2 can be obtained through the NASA Glenn Software Repository (`https://technology.grc.nasa.gov/software`).

The code is still under development and is furnished as is, with no warranty of fitness for any particular use. You are not permitted to give the SmaggIce code to any other organizations and/or persons outside your company. We would be interested in knowing about any problems or errors that you experience with the code, as well as any new features you would like to see included in future releases.

Contact Information

Questions and comments can be sent via e-mail to:
`smaggice@grc.nasa.gov`

Capabilities

SmaggIce version 1.2 provides two types of software tools: interactive ice shape characterization and geometry preparation. The ice shape characterization tools provide users the means to measure the physical characteristics of ice such as icing limit locations, horn height and angle, and distance from the leading edge to any prominent ice location. The geometry preparation includes: ice shape control, computer-generated (artificial) ice creation and rotation/translation of the geometry. The ice shape control features provide the means to examine input geometry data, correct or modify any deficiencies of them, and perform a systematic smoothing of ice to a level that will make the CFD process manageable. The artificial ice creation tool provides users with geometries (such as triangle, rectangle, semi-circle, etc.) that can be attached to the geometry surface to prepare for studies of the effects of various ice shapes on aerodynamic performance. The Move Element tool allows the user to rotate and/or translate airfoil components.

Ice Shape Characterization

The interactive ice shape characterization process involves making measurements of the data on the screen, recording those measurements in a

table, and saving them to a file. After the boundary data is read in, the user can make probing measurements. These include: point location (e.g., ice limits), distance between two points (e.g., ice horn height or width), arc length (i.e., the sum of the lengths of the line segments along a boundary between two points on that boundary), angle between two lines (e.g., horn angle), x-location of a point relative to the leading edge, and ice area (the area between a segment of the ice and the corresponding segment of the clean airfoil). Location and distance may be normalized by the chord length of a clean airfoil. Ice area may be normalized by the area of the clean airfoil. The points used in measuring can be selected by various methods: the closest point to any object, the closest point to the current object, the closest point to the reference object, or an arbitrary point in space. Measurement information may be saved to a text file and a corresponding graphics display can be saved to an image file.

Geometry Preparation

Ice Shape Control

Interactive ice shape control is used to prepare the surface for gridding. The types of functions that can be applied to surfaces are curve smoothing, re-discretization, point redistribution, and correction of obvious input errors such as a twisted ice surface. Any subcurve (or the entire curve) of an element can be selected for processing. Systematic smoothing of the iced boundaries in a controlled manner is accomplished using a control point formulation. With this feature, a user can smooth irregular ice surfaces to a level acceptable to his/her grid generation tools. Users can control the level of smoothing by choosing the number of control points in constructing curves. Direct reshaping of the curve is done by dragging control points associated with the curve. Curve re-discretization provides a means of increasing/decreasing the number of points, distributing the points by curvature, and controlling the uniformity of their distribution. In addition, hyperbolic tangent stretching is provided. These control features of SmaggIce not only prepare the ice surface for gridding and CFD flow simulation, but they also allow users to correct any deficiencies (e.g., twists, gaps, too many or too few points) in the input data.

Computer-generated (Artificial) Ice Creation

Adding computer-generated ice shapes to the surface of a clean airfoil is used to prepare for studies of the effects of surface roughness as well as various ice shapes on the airfoil aerodynamic performance. Once the clean airfoil data is read in, the user may interactively add different types of geometries to the clean airfoil. These geometric ice shapes include:

forward-facing right triangle, backward-facing right triangle, generic triangle, rectangle, forward-facing quarter circle, backward-facing quarter circle, semi-circle and trapezoid. The user is able to set/modify parameters defining the artificial ice geometry.

Move Element

With this feature, the user can modify elements by rotating and/or translating the geometry. This may be useful to prepare for parametric studies on multi-element configurations. For instance an aileron can be translated and rotated about a user-specified hinge point.

Implementation Issues

SmaggIce is written in FORTRAN and C. FORTRAN is used for some computational routines; C is used for the GUI, control, interaction, graphics, and memory management.

SmaggIce is intended to run on UNIX and MS-Windows platforms. It has been tested on SGI, Sun, Linux, and several MS-Windows platforms. The GUI was developed for the X Window System, using Motif, Xt Intrinsics, and Xlib functions (Figure 1). This will aid in the portability of the user interface across multiple computer platforms running X. Whenever possible, the GUI uses higher level libraries (Motif widgets) rather than the functionally equivalent Xt or Xlib libraries, because the higher-level code hides many of the details. This makes the code less complex, so the application is more easily maintained.

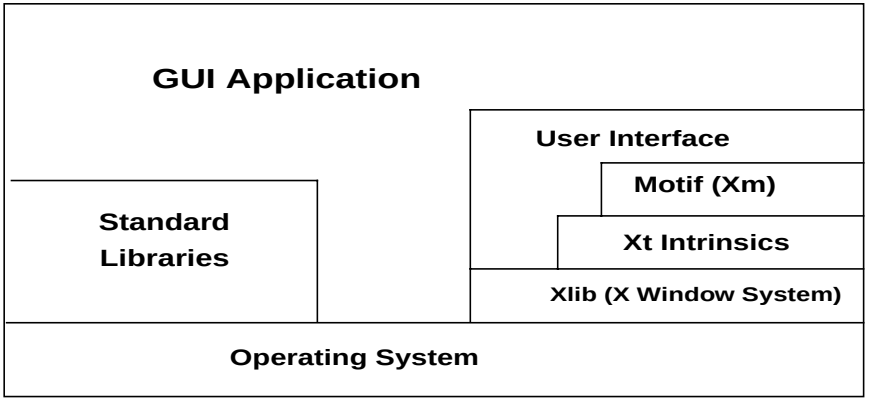

Figure 1. Diagram of the user interface library model.

The GUI provides a graphical mechanism for the user to interactively perform SmaggIce functions such as: reading data, displaying 2D graphics objects, performing geometric transformations (such as translation, scaling, area zoom, zoom in, zoom out), and saving data and images to files.

OpenGL is used for the graphics drawing. It uses the GLX extensions to X to interface with the windowing system, but the Mesa library can be used if the client workstation does not have OpenGL or if the X server does not support the GLX extensions.

Dynamic memory management is used to allocate only as much memory as is necessary for data storage and access. This allows the program to process models whose size is limited only by the amount of memory on the host computer. It also allows multiple input files to be read in and processed during a single session. In addition, when data is no longer needed during a session, it can be cleared to allow for reading in new data. The data structures that make use of dynamic memory in SmaggIce version 1.2 are illustrated here (Figure 2). As objects are read in, memory is allocated for them to store the object type as well as attributes describing the object. Space is also allocated for the data points defining the geometry, and a pointer stored with the object. When additional objects are read in, or as geometry is modified (e.g., points are added), memory is reallocated as needed. When objects are deleted, the memory is freed to make room for new objects.

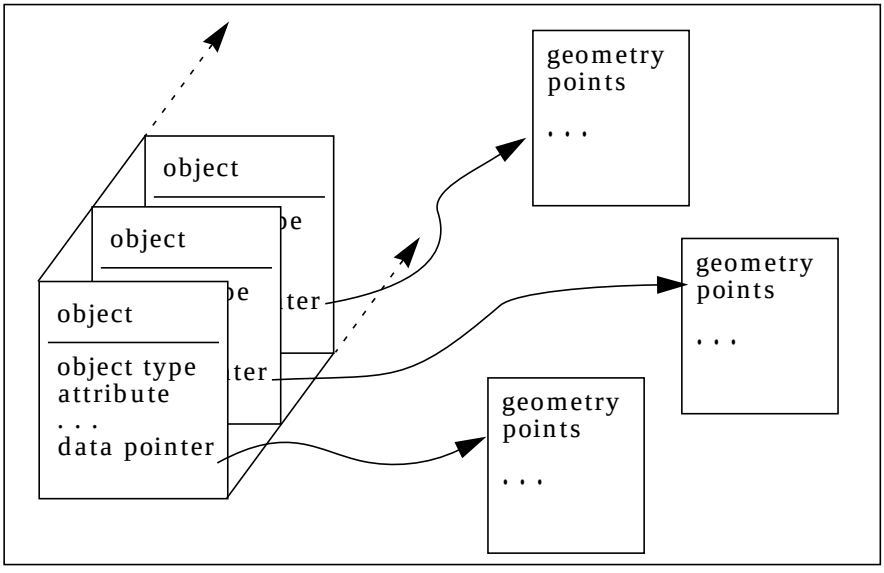

Figure 2. Data structures for multiple objects using dynamic memory.

CHAPTER 2

Access and Installation

How to Get SmaggIce

This computer program is available to any U.S. organization upon request. It is furnished on the condition that it will be used only within and for the U.S. organization which requests the software, and that it will not be transmitted to other organizations.

Requests for software may be submitted through the Glenn Software Repository (https://technology.grc.nasa.gov/software).

System Requirements

SmaggIce was designed and written to run on any UNIX or MS-Windows platform. It has been built for the following systems:

SGI IRIX 6.5 (32 bit) using X and OpenGL
SGI IRIX 6.5 (32 bit) using X without OpenGL
SUN SunOS 5.8 using X and OpenGL
SUN SunOS 5.8 using X without OpenGL
Intel Linux 2.4.18 using X and OpenGL
Intel Linux 2.4.18 using X without OpenGL
MS-Windows 98 using X-server with GLX extension
MS-Windows 98 using X-server without GLX extension
MS-Windows NT using X-server with GLX extension
MS-Windows NT using X-server without GLX extension
MS-Windows 2000 using X-server with GLX extension
MS-Windows 2000 using X-server without GLX extension

Currently, SmaggIce v1.2 is only distributed as a binary executable. If you need a version of SmaggIce for a platform that is not included in the distribution, please contact the SmaggIce team: smaggice@grc.nasa.gov.

Requirements for UNIX Platforms

To run a SmaggIce on a UNIX platform, you should have the following:

- Netscape web browser software for viewing help files
- If you are using the SmaggIce package that uses OpenGL, you must have the OpenGL libraries installed on your system.

Requirements for MS-Windows Platforms

To install and run SmaggIce on a PC running Microsoft Windows, you should have the following:

- Pentium-class PC (300MHz or higher recommended)
- 32 megabytes of Random Access Memory (64 MB of RAM recommended)
- disk space (MB = megabytes):
  - for CD installation: 20 MB during installation and 10 MB after the install is complete
  - for Web download: 25 MB before installation and 10 MB after the install is complete
- Super VGA monitor (or better)
- standard graphics card (or better)
- Windows 98, Windows Me, Windows NT 4.0 with Service Pack 6, Windows 2000, or Windows XP installed as the operating system
- administrative privileges on the system (for installation on Windows 2000 or Windows NT only)
- Microsoft Internet Explorer or Netscape web browser software for viewing help files
- third party X-server software already installed on your PC (available from various sources)
- If you are using the SmaggIce package with GLX extensions, you will need OpenGL extensions (GLX) installed with your X-server software.

If you decide to run any version on a MS-Windows platform, then you must have already installed an X-server (for example, Hummingbird's Exceed). SmaggIce has been tested with several X-servers. See Table 1 below for a comparison of the test results. If you choose other X-servers, then your results may vary. Furthermore, if you want to use GLX extensions, then you must also install libraries to support GLX extensions (for example, Hummingbird's Exceed3D)

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	PC X-servers				
	EXCEED	**HOBLink**	**MI/X**	**Wina/XE**	**X-ThinPro**
Approximate price	$300	$69	$25	$100	$90
Fonts included	yes	yes	no	yes	yes
Menu bar accelerator (Alt-key)	no	yes	no	yes	yes
Mouse button support	two	three	three	two	three
Screen Save	yes	yes	no	yes	yes
Supports GLX version of SmaggIce	requires Exceed3D (extra $125)	no	no	no	yes
Windowless X-Server	yes	yes	no	yes	yes

Table 1. X-servers tested with SmaggIce

This table contains a sample of various software products providing X-Window Server services. It is intended to be a guide to the SmaggIce user. NASA is not endorsing any of these products.

Distribution

SmaggIce is distributed on a CD-ROM or through download. The distribution package contains:

1. README file with a description of the CD-ROM contents, and directions for installation and startup.
2. Executable SmaggIce version 1.2.
3. Sample input geometry files used in the tutorial.
4. This User Manual in Postscript and PDF format.
5. On-line help files in HTML format.
6. Auxiliary files needed to set up and run SmaggIce.

The MS-Windows distribution comes in 2 separate packages: the GLX package containing the SmaggIce executable that uses GLX extensions; or the non-GLX package containing the SmaggIce executable without GLX extensions (using instead only standard X routines). If you have any questions about which package to request, contact the SmaggIce team.

UNIX Installation

1. Create a directory to hold the SmaggIce files and change to that directory. For example:

   ```
   > mkdir $HOME/smaggice1.2
   > cd $HOME/smaggice1.2
   ```

2. If you are installing from a CD, copy the contents of the CD to this directory:

   ```
   > cp -r /CDROM/* .
   ```

   If you are installing from a download, uncompress and extract the files to this directory. For example;

   ```
   > gunzip -c /tmp/smaggice12.tar.gz | tar xovf -
   ```

3. Edit the file `bin/runsmagg`. Detailed directions are in the file.

   You will have to set at least two environmental variables in that file:
   `SMG_DIR` - directory into which the SmaggIce distribution was copied
   `SMG_VENDOR` - the architecture on which you are running

   On some systems, you have the option of displaying the graphics using OpenGL or X only (without OpenGL). The default is to run the OpenGL version, if it is available. If you would rather run the X-only version, that option can be set here.

   To display on-line help, you may need to set the variable `WEBBROWSER`.

MS-Windows Installation

NOTE: To install SmaggIce on Windows NT or Windows 2000, you must log onto an account with administrative rights.

Installation from a CD:

1. Insert the SmaggIce for Windows distribution CD-ROM into a CD-ROM drive (usually D:) and Autorun will automatically start the installation program.
2. If Autorun does not start, then double click on the file “setup.exe” located under the root directory of the CD-ROM drive (typically, D:\setup.exe).
3. The install window will appear. Follow the directions that appear on the screen.

Installation from a downloaded Zip file:

1. Download (via FTP) the file "SmaggIce v1.2.zip" from the location specified by the Commercial Technology Office (CTO) at Glenn Research Center to a folder on your local hard drive (for example, C:\TEMP\SmaggIce). This compressed file contains the SmaggIce for Windows distribution.
2. Unzip the downloaded file via WinZip (or other compatible decompression programs) into the download folder (C:\TEMP\SmaggIce).
3. Double click on the file "setup.exe" in that download folder (C:\Temp\SmaggIce\setup.exe).
4. The install window will appear. Follow the directions that appear on the screen.

Uninstalling SmaggIce from a Windows PC

If you need to uninstall SmaggIce, use the Add/Remove Programs control panel (Start button|Settings|Control Panel|Add/Remove Programs). Highlight the SmaggIce entry and click the **[Remove]** button.

NOTE: You should always do this uninstall before re-installing SmaggIce. Do NOT try to install another SmaggIce package (GLX or non-GLX) without first uninstalling the package that is currently installed.

Problems/Questions

We would be interested in knowing about any problems or errors that you experience with the code, as well as any new features you would like to see included in the future.

If you need additional assistance, please contact the developers:

Yung K. Choo at (216) 433-5868 or
e-mail: smaggice@grc.nasa.gov
fax: (216) 977-7469

CHAPTER 3

Usage

Starting SmaggIce on a UNIX system

Before starting SmaggIce, be sure you have modified the `runsmagg` script (which can be found in the `smaggice1.2/bin` directory), as described in step 3 of the Installation instructions.

To run SmaggIce, invoke the `runsmagg` script in the `smaggice/bin` directory by specifying its full pathname. For example, if you have installed SmaggIce in the directory `$HOME/smaggice1.2`, type:

```
> $HOME/smaggice1.2/bin/runsmagg
```

Alternatively, you may wish to add the `smaggice1.2/bin` directory to your path, then simply type:

```
> runsmagg
```

The SmaggIce main window will be displayed.

Starting SmaggIce on a MS-Windows system

Follow these steps to run SmaggIce:

- If you will be running the GLX version of SmaggIce, make sure that the GLX extensions are enabled in your X-server software (see your X-server documentation);
- Start your X-server BEFORE running SmaggIce (consult your X-server documentation);
- Start SmaggIce via any of these alternatives:
  - double-click on the desktop shortcut,
  - click on the Start button|Programs|SmaggIce|Run Smaggice, or
  - locate `smaggrun.bat` in Windows Explorer and double-click on it.

The SmaggIce main window will be displayed. If this main window does not appear within a few seconds, then check to be sure that you started the X-server before starting SmaggIce.

If the on-line help does not work, then edit the file "`smaggrun.bat`", and set the variable `WEBBROWSER`.

Usage Overview

SmaggIce deals with two main types of objects: elements and blocks. An element is either the entire or partial boundary of a solid. A block is a section of the flow domain. For example, an element may be a clean or iced airfoil, or an isolated ice shape between upper and lower ice limits. Elements are typically processed in preparation for gridding to correct input errors, smooth the boundary, increase or decrease the number of points, and/or redistribute the existing points. Version 1.2 provides tools for working with elements only.

Since SmaggIce allows you to work with multiple objects, it must necessarily support the concept of a "current object". Details of how to switch between objects and modify those objects are given in the next chapter.

Many SmaggIce functions are performed on subcurves of objects. Details of how to select and modify subcurves are also given in the next chapter.

As you begin using SmaggIce, you will see that the GUI is designed to provide "directed control" or "guided use". This means that you will be prevented, through the desensitization of controls (menus, buttons, sliders, etc.), from selecting conflicting functions or functions that are invalid in certain situations.

Error checking is performed at all levels, starting at the GUI, whenever you enter parameters. Any errors such as out-of-range data or invalid values are immediately reported so that you can correct them.

CHAPTER 4

User Interface

SmaggIce Main Window

SmaggIce consists of a primary Main Window titled “SmaggIce - Surface Modeling and Grid Generation for Iced Airfoils” and sub-windows called:

- File Open
- Save As
- Screen Save
- Messages
- Ice Shape Characteristics
- Save Probe Information
- Add Artificial Ice
- Move Element
- Discretize Subcurve
- Change Free Form Subcurve
- Tanh Redistribution

The SmaggIce Main Window (Figure 3) is recognized by the following distinctive areas: **Menu Bar** (*File*, *Edit*, *View*, *Element*, *Boundary*, and *Help* pulldown menus), **Information** area, **Current Object Info**, **Graphics Window Mode**, View Manipulation Icons, and Graphics Drawing area. Sometimes items are “grayed-out” when certain selections have been made. This means that the item is temporarily unavailable. An example of this is the *Save As* or *Screen Save* selection. These are “grayed-out” when the user starts the application, because no data has been read, so there is nothing that can be saved.

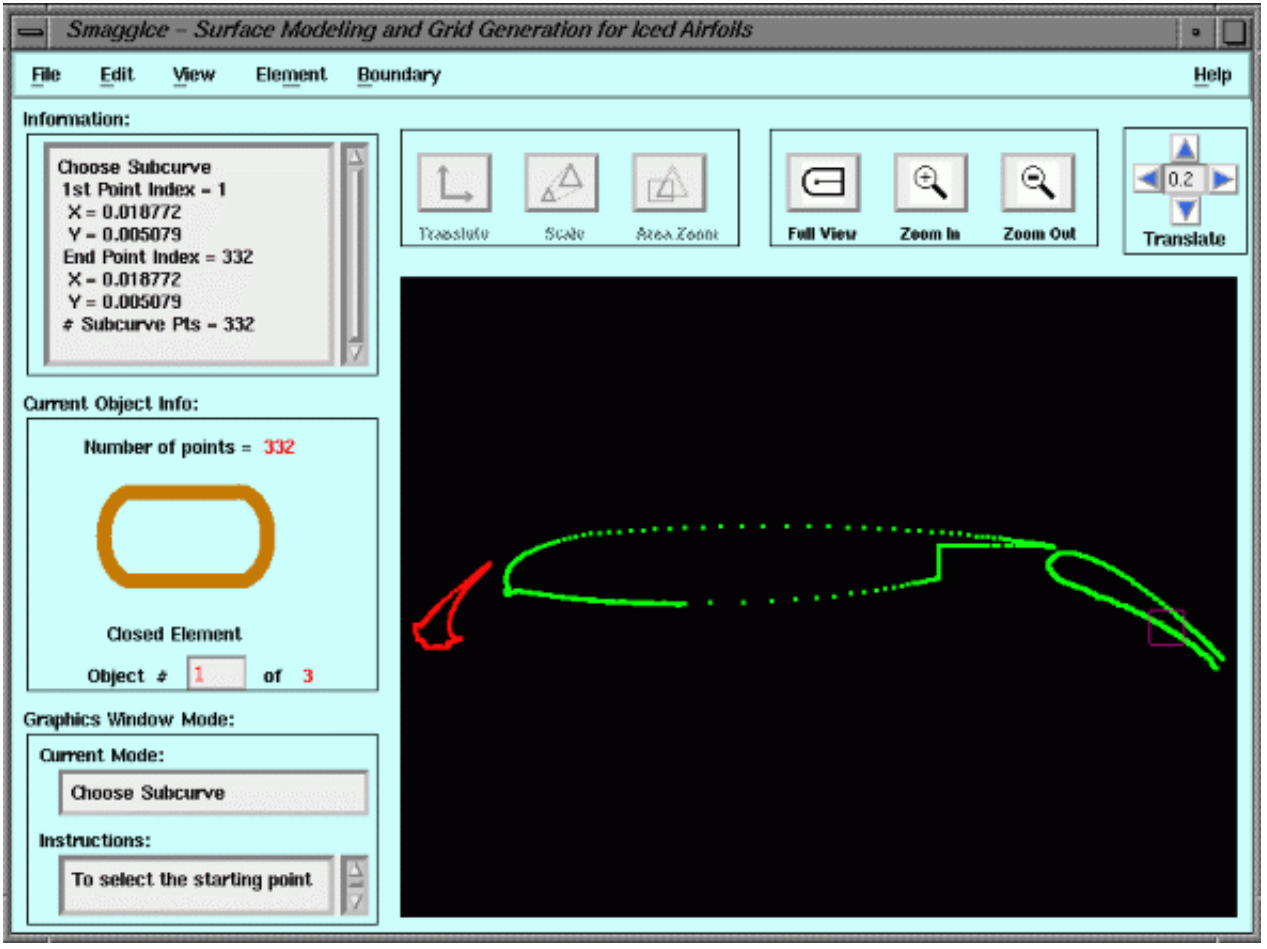

Figure 3. SmaggIce Main Window

Menu Bar

There are six menu items in the Menu Bar: *File*, *Edit*, *View*,*Element*, *Boundary*, and *Help*. Each of these will be described later in the manual section titled “Menu Bar” (p. 19).

Information

While the user interacts with the graphics window, relevant information is displayed in the **Information** scrollable text area (Figure 4). For example, while measuring ice shapes, the coordinates of points are displayed here. As another example, when a subcurve is being selected, information on the subcurve endpoints is displayed here.

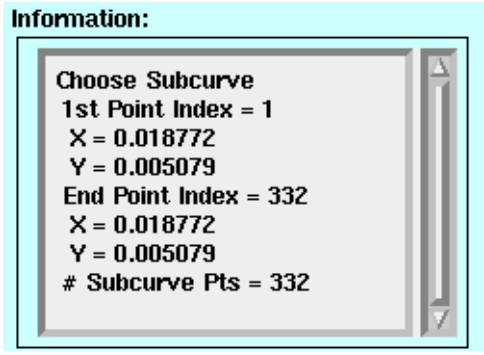

Figure 4. Information Area showing subcurve endpoints

Current Object Info

This area displays information about the current object such as: the type of object, its index number, and a graphic representation of the object (Figure 5). For example, when an element is selected, the number of points in the element is displayed, along with an indication of whether it is an open element or closed element. To switch to another object, making it the current object, the user may type its index in the **Object #** text box and press <Enter>. There is a non-editable textfield showing the total number of objects that are currently available.

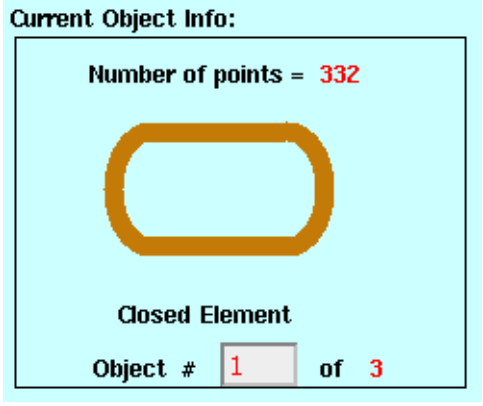

Figure 5. Current Object Info

Graphics Window Mode

The current mode is displayed here, along with instructions (Figure 6). Some of the graphics window modes are Translate, Scale, Area Zoom, Choose Subcurve, and Display Point Coordinates. Depending on the mode, mouse movements and button clicks in the graphics window will have different effects. How to use the mouse in each mode is described in the **Instructions** scrollable text area.

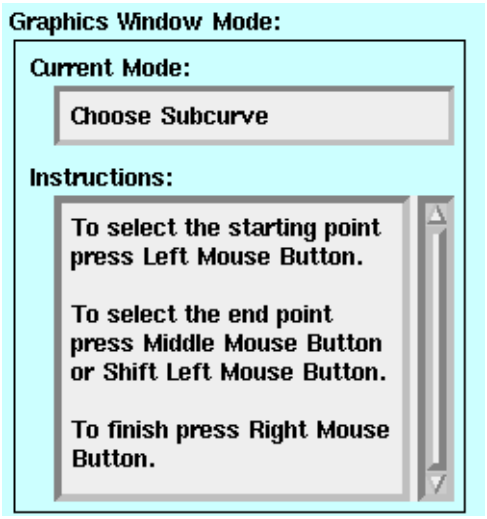

Figure 6. Graphics Window Mode

View Manipulation

These icon push buttons (Figure 7) modify the user's view of the geometry without changing the data itself. The first set of buttons, labeled **[Translate]**, **[Scale]**, and **[Area Zoom]**, set the graphics window mode so that mouse button presses and movements modify the view continuously. **[Translate]** moves the geometry around on the screen without changing its size. **[Scale]** changes the apparent size of the geometry. **[Area Zoom]** allows a user to draw a box around an area of interest and zoom into that area. Instructions for how to use the mouse in each instance is displayed in the **Instructions** area in the **Graphics Window Mode** area. The second set of buttons, labeled **[Full View]**, **[Zoom In]**, and **[Zoom Out]**, change the view immediately when the user presses one of them. **[Full View]** modifies the view to include all geometry. **[Zoom In]** makes all geometry appear a little larger. **[Zoom Out]** makes all geometry appear a little smaller. The last set of arrow buttons labeled **Translate** also changes the view immediately. When an arrow button is pressed, it will move the geometry the indicated fraction of the screen width in that direction. The fraction value may be changed by typing another value in the text box. The default value is 0.2.

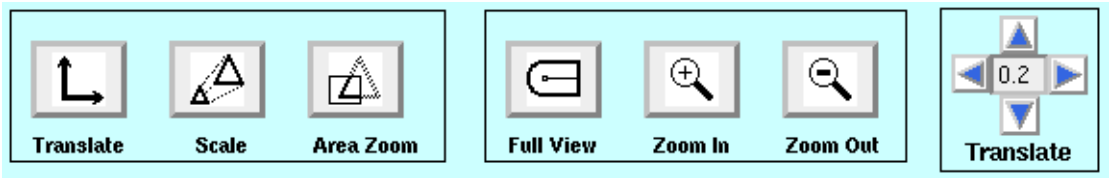

Figure 7. View Manipulation Icons

Graphics Drawing Area

The Graphics area is where geometry is displayed and direct interactive manipulation of the geometry is performed. Depending on the current graphics window mode, mouse button presses and movements will have different effects. Instructions for interactions in each mode is described in the **Instructions** area in the **Graphics Window Mode** area.

Menu Bar

This section gives information on the six components of the Menu Bar: *File*, *Edit*, *View*, *Element*, *Boundary*, and *Help*.

File

There are four actions that can be selected from the File Menu. They are *Open*, *Save As*, *Screen Save*, and *Exit* (Figure 8).

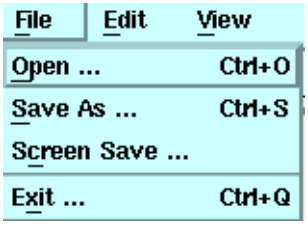

Figure 8. File pulldown menu

Open - Displays the ***File Open*** window (Figure 15, p. 25). This window allows the user to select and read the geometry. The hot key for this menu pick is <Ctrl>O. For more information, see the section “File Open” (p. 25).

Save As - Displays the ***Save As*** window (Figure 16, p. 29). This window allows the user to save the geometry of objects to a file. The hot key

for this menu pick is <Ctrl>S. For more information, see the section “Save As” (p. 29).

Screen Save - Displays the ***Screen Save*** window (Figure 17, p. 30). This window allows the user to save the Graphics Window as an image file. For more information, see the section “Screen Save” (p. 30).

Exit - Quits the SmaggIce application. A confirmation screen is presented before exiting. The hot key for this menu pick is <Ctrl>Q.

Edit

The available options are *Clear All* and *Delete Subcurve* (Figure 9).

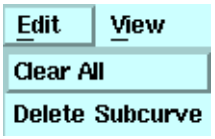

Figure 9. Edit pulldown menu

Clear All - Removes all the data objects from the Graphics Window and sets most of the attributes of SmaggIce back to their initial state, as when the program started.

Delete Subcurve - Deletes the currently selected subcurve, including its endpoints. A confirmation screen is presented before the curve is actually deleted. After deletion, the currently selected subcurve will be reset to include all the remaining points on that element. The subcurve cannot be deleted if less than two points would be left in the element.

View

This menu allows the user to access the following: *Display Point Coordinates*, *Highlight Twisted*, *Highlight Reference Airfoil*, *Display Glyphs*, and *Messages* (Figure 10).

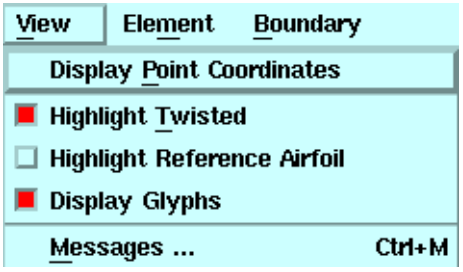

Figure 10. View pulldown menu

Display Point Coordinates - Once the user has selected this option, the graphics mode will be changed to "Display Point Coordinates", so that each left mouse button press in the graphics window will select the closest boundary point in the current object. The point will be highlighted in the graphics display, and its index and (x,y) coordinates in input data units will be displayed in the **Information** area. Instructions for selecting the closest point with the mouse button will be displayed in the **Instructions** area in the **Graphics Window Mode** section of the main screen.

Highlight Twisted - Turns on or off highlighting of twists (intersecting lines along the boundary) in elements. When an element is read in or after it is modified in the ***Change Free Form Subcurve*** window, a search is made for twists in that element. Up to 25 intersections may be found. If this toggle is on, the intersecting line segments will be highlighted, and a box will be drawn around the point of intersection. If the curve is later modified so as to remove the twists, the highlighted lines and box will be removed.

Highlight Reference Airfoil - Turns on or off highlighting of the reference airfoil. If a reference airfoil has been set and this toggle is on (i.e., the box is colored), the reference airfoil will be highlighted. Two additional reference points will also be displayed and selectable during measurement operations: the leading edge point, and the center of the leading edge circle. If this toggle is off, the reference airfoil will be displayed in the same colors as all other objects, and the two additional reference points will not be displayed or selectable. To set the reference airfoil, make the reference airfoil the current object, and then select *Element->Set Reference Airfoil* from the main menu.

Display Glyphs - Sets the visibility of the measurement glyphs "On" or "Off". If this toggle is checked (i.e., the box is colored), the glyphs (lines and points representing measurements that are made during ice shape characterization) will be shown in the graphics display area, overlaid on the geometry. Turning off this toggle will turn off the display of these glyphs. However, the glyphs will continue to be defined (and displayable by setting the toggle on again), until *Edit->Clear All* is chosen from the main menu, or the **[Clear All]** button is pressed on the ***Ice Shape Characteristics*** window.

Messages - Displays the ***Messages*** window (Figure 11). This scrollable window keeps a running log of information, warning, and error messages. The hot key for this menu pick is `<Ctrl>M`.

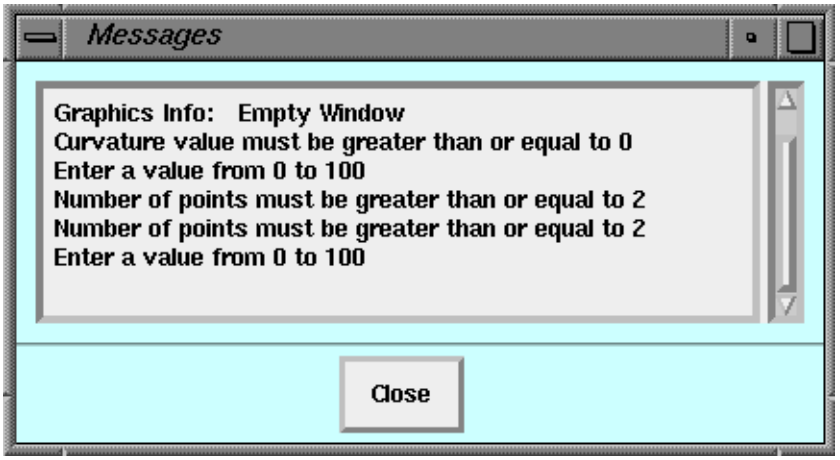

Figure 11. Messages

Element

This menu allows the user to access the following: *Ice Shape Characteristics*, *Set Reference Airfoil*, *Add Artificial Ice*, and *Move Element* (Figure 12).

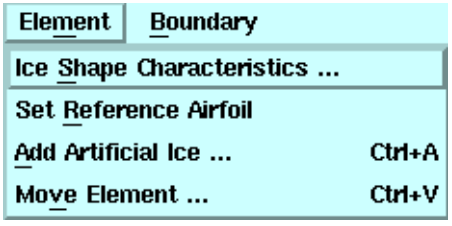

Figure 12. Element pulldown menu

Ice Shape Characteristics - Displays the ***Ice Shape Characteristics*** window (Figure 18, p. 31). This window allows the user to make geometry measurements (such as location, length, arc length, angle, (X-Xle)/C, and ice area) using various point selection methods (such as: all objects, current object, reference airfoil, and arbitrary point). The measurement information will entered in the **Probe Info Table**, and the user can later save those measurements to a file. For more information, see the section “Ice Shape Characteristics” (p. 30).

Set Reference Airfoil - Identifies the current object as the reference airfoil. A reference airfoil is usually one without ice accretion and is used to determine the chord length and leading edge point. A reference airfoil must be set before making some measurements such as

normalized length or (X-Xle)/C. To set the reference airfoil, set the current object to be the airfoil, and then select *Element ->Set Reference Airfoil* from the main menu.

Add Artificial Ice - Displays the ***Add Artificial Ice*** window (Figure 19, p. 35). This window allows the user to add computer-generated artificial ice shapes (such as: triangle, rectangle, semi-circle, and trapezoid) to the surface of a clean airfoil to study the effects of the various ice shapes on the aerodynamic performance. The hot key for this menu pick is <Ctrl>A. For more information, see the section "Add Artificial Ice" (p. 34).

Move Element - Displays the ***Move Element*** window (Figure 21, p. 37). This window allows the user to translate the current element and/or rotate it about a hinge point. All user input values are relative to the original data. The hot key for this menu pick is <Ctrl>V. For more information, see the section "Move Element" (p. 37).

Boundary

There are five actions that can be selected from the Boundary Menu. They are *Choose Subcurve*, *Discretize Subcurve*, *Change Free Form Subcurve*, *Tanh Redistribution*, and *Switch Object* (Figure 13).

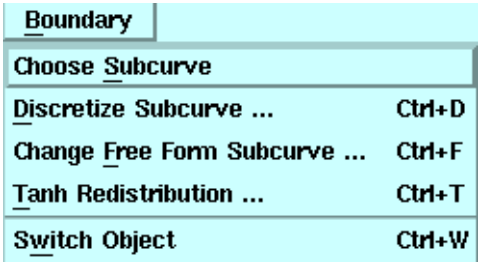

Figure 13. Boundary pulldown menu

Choose Subcurve - Selects the subcurve for the current object. The points on the selected subcurve are displayed in red, while the other points of the current element are displayed in yellow. By default, when an element is read in, the subcurve is the entire boundary. Several functions in SmaggIce (such as Discretize Subcurve, Change Free Form Subcurve, and Tanh Redistribution) are performed on "subcurves". Instructions for setting the endpoints of the subcurve will be displayed in the **Instructions** area in the **Graphics Window Mode** area of the main screen. To choose one point over the other from the overlapped points of a closed element, select a point close to the overlapped point, then use the left and right arrows to change the selection to points on either side.

Discretize Subcurve - Displays the ***Discretize Subcurve*** window (Figure 22, p. 38). This window allows the user to discretize the selected subcurve of the current object. The new discretized points are displayed as blue crosses overlaid on the graphics display. The hot key for this menu pick is `<Ctrl>D`. For more information, see the section "Discretize Subcurve" (p. 38).

Change Free Form Subcurve - Displays the ***Change Free Form Subcurve*** window (Figure 23, p. 39). This window allows the user to change the shape and smoothness of the selected subcurve by using control points. The hot key for this menu pick is `<Ctrl>F`. For more information, see the section "Change Free Form Subcurve" (p. 39).

Tanh Redistribution - Displays the ***Tanh Redistribution*** window (Figure 24, p. 41). This window allows the user to redistribute the points of the selected subcurve of the current object using a hyperbolic tangent redistribution method. The new point locations are displayed as blue crosses overlaid on the graphics display. The hot key for this menu pick is `<Ctrl>T`. For more information, see the section "Tanh Redistribution" (p. 41).

Switch Object - Sets the current object to be the next one in the list of available objects. SmaggIce has the concept of a "current object", which is the object upon which functions are performed. This menu selection allows the user to switch to the next object in the list of available objects. The current object is displayed as red (and possibly yellow) points, while the other objects are displayed as green points. The hot key for this menu pick is `<Ctrl>W`. The user may also switch to another object by typing the object number into the **Object #** text box in the **Current Object Info** area of the main screen and pressing `<Enter>`.

Help

This menu allows the user to access the following: *On Version*, *Online Help*, and *Hints* (Figure 14).

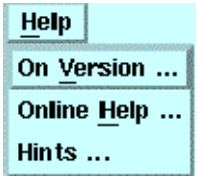

Figure 14. Help pulldown menu

On Version - Displays the following information: SmaggIce version, release date, copyright, and e-mail address of the contact person.

Online Help - Displays online HTML documentation. For more information, see the section “Online Help - UNIX” (p. 42).

Hints - Lists the most frequently asked questions.

File Open

The ***File Open*** window allows the user to select and read geometry (Figure 15). The user selects from the **File Type** option menu the type of data to be read in. There are three file types available: *Element Boundary*, *IRT Element* and *LEWICE Element*. An element is an object boundary. There are two different kinds of element boundaries. An open element has the first and last points at different x,y coordinates. A closed element has the first and last points at the same x,y coordinates.

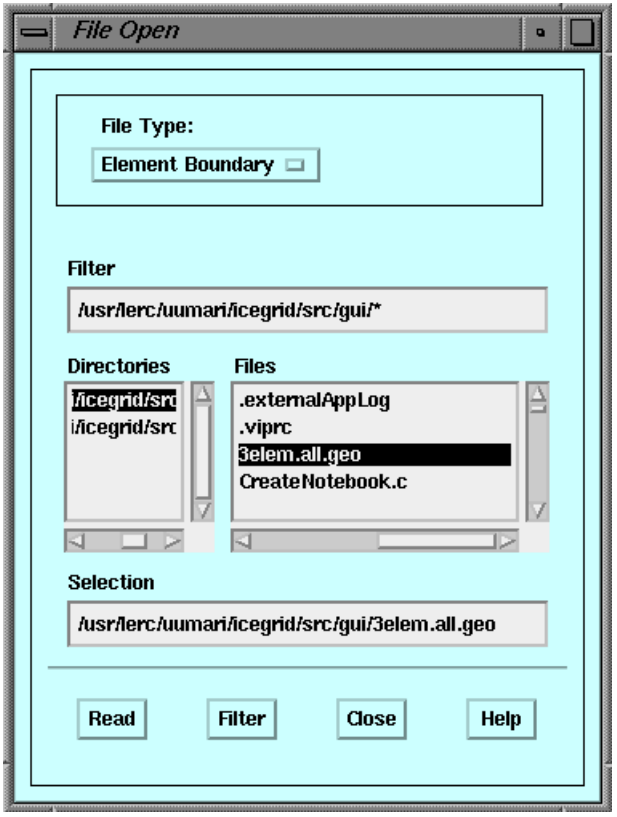

Figure 15. File Open Window

The following controls are used to specify the file to be read: **Filter**, **Directories**, **Files**, and **Selection**.

Filter - Filters or limits the filenames displayed in the **Files** list box. The directory initially displayed in this input box is the current directory (the one from which SmaggIce was started). The user may also type directly into the **Filter** text box the full path followed by a filename which may include an * to match any string of characters. Then press the **[Filter]** button at the bottom of the window.

Directories - Lists the directories matching the pattern in the **Filter** input box. If more names exist than can be displayed in the list box, the scrollbar will allow the user to move through the list. The user can navigate through directories by double-clicking on an entry in this list.

Files - Lists the filenames matching the pattern in the **Filter** input box. If more names exist than can be displayed in the list box, the scrollbar will allow the user to move through the list. To read a file from this list, click on the filename and press the **[Read]** button, or just double-click on the filename.

Selection - Displays the path and filename of the file which will be read. If the desired filename is not displayed, use **Filter**, **Directories**, and **Files** to select the desired filename, or type the name of the path and file in this area. If the **Selection** input box already contains a name, the user can edit the name as in any input box. Pressing <Enter> after typing the filename is equivalent to clicking the **[Read]** button or double-clicking on a filename.

File Type

Three types of files may currently be read in, all of which define elements:

- Element Boundary (SmaggIce default)
- IRT Element (data from the Glenn Icing Research Tunnel as tabulated in NASA/TP-2000-210031/SUPPL)
- Lewice Element (as output by Lewice software)

All point data is read in and stored as double-precision.

Element file format

An element file contains data for one or more elements. The file consists of the following information, in the following order.

- Optional comments at the beginning of the file; # at the beginning of the line marks a comment line
- The number of elements defined in this file
- For each element:
  - The number of points in the element
  - Two columns, separated by spaces, containing the x,y coordinates of each point

Comments (indicated by a #) may be embedded anywhere in the file. Everything on the line after the # is ignored.

SmaggIce default file example

```
# this file contains 2 elements
# an open square with 4 points,
# a closed hexagon with 7 points (only 6 of which are distinct)
2      # number of elements
4      #number of points in 1st element
 .1 .1 #start of points of the square (1st element)
 .3 .1
 .3 .3
 .1 .3
7      #number of points in 2nd element
 .5 .3 #start of point of the hexagon (2nd element)
 .7 .3
 .8 .5
 .7 .7
 .5 .7
 .4 .5
 .5 .3 #last point is same as the 1st point; this element is closed
```

IRT file format

An IRT file contains only two elements: a clean airfoil and the ice on that airfoil. It consists of the following information, in the following order.

- Comments at the beginning of the file; a row of at least 10 equal signs (==========) marks the end of the comment section
- Four columns of data, separated by space
  1st column contains the x-coordinates of the clean airfoil
  2nd column contains the y-coordinates of the clean airfoil
  3rd column contains the x-coordinates of the ice
  4th column contains the y-coordinates of the ice

The clean airfoil and the ice data do not necessarily have the same number of points, but if there are less points in the clean airfoil, blanks must be left in those columns.

IRT file example

```
Commercial Transport - Run 145m
Coordinates:
Clean                  Airfoil          30″             Tracing
X/c                      Y/c            X/c               Y/c
=================================================================
1.000                    0.009          0.032             -0.018
0.782                 -0.011            0.023            -0.022
0.539                 -0.030            0.023            -0.017
0.295                 -0.034            0.012            -0.019
0.066                 -0.023            0.011            -0.013
0.000                  0.000            0.005            -0.013
0.086                  0.042            0.004            -0.009
0.287                  0.056           -0.003            -0.011
0.555                  0.050           -0.014            -0.015
0.797                  0.029           -0.022            -0.018
1.000                  0.010           -0.018            -0.009
                                       -0.015            -0.008
                                       -0.007            -0.002
                                       -0.007             0.008
                                       -0.018             0.013
                                       -0.020             0.022
                                       -0.008             0.018
                                        0.004             0.014
                                        0.008             0.020
                                       -0.001             0.030
                                        0.009             0.027
                                        0.023             0.025
```

Lewice file format

A Lewice file contains data for only one element. The file consists of the following information, in the following order.

- the number of points in the element
- two columns, separated by spaces, containing the x,y coordinates of each point

Lewice file example

```
4
 .1 .1
 .3 .1
 .3 .3
 .1 .3
```

Save As

The ***Save As*** window allows saving elements to an Element file in the default SmaggIce format (Figure 16). The **Save Object** option determines which objects are written to the file:

Current Object - only the current object is written to the file

All Elements - all existing elements are written out to a single file in the SmaggIce element file format.

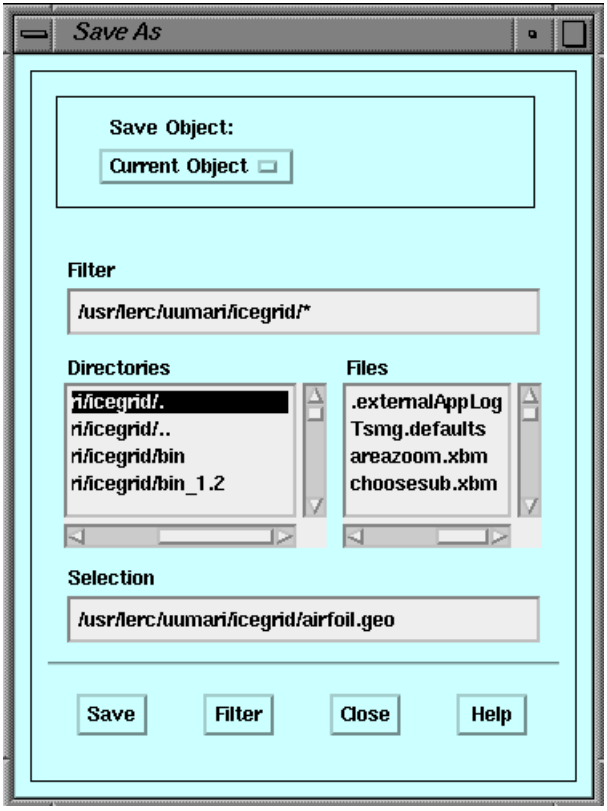

Figure 16. Save As Window

The following controls are used to specify a file where the data will be saved: **Filter**, **Directory**, **Files**, and **Selection**.

Selection - Displays the path and filename of the file that will be written.

For the full description of all other controls, see page 26 under the section “File Open window”.

Screen Save

The ***Screen Save*** window allows the user to save the image in the Graphics Window to a file (Figure 17). The **File Type** option menu determines the type of image file that will be saved: *GIF*, *TIFF*, or *PPM* (portable pixmap). The rest of the controls are used the same way as in the ***File Open*** and ***Save As*** windows.

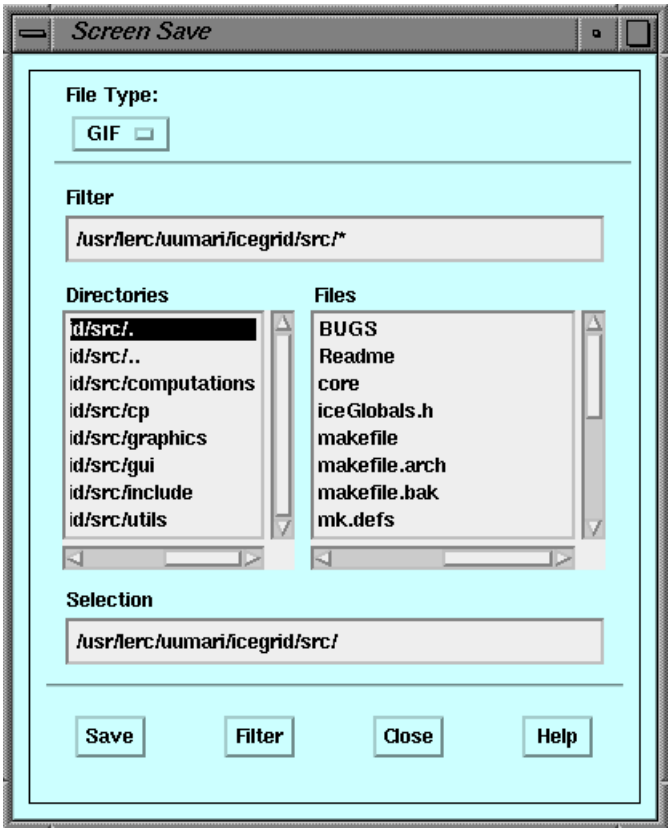

Figure 17. Screen Save Window

Ice Shape Characteristics

The ***Ice Shape Characteristics*** window allows the user to make measurements (such as location, length, arc length, angle, (X-Xle)/C, and ice area) using various point selection methods (such as all objects, current object, reference airfoil, and arbitrary point) (Figure 18). The user

can enter the measurement information in the **Probe Info Table**, and this information can be saved to a file. This window consists of parameters, controls, and buttons.

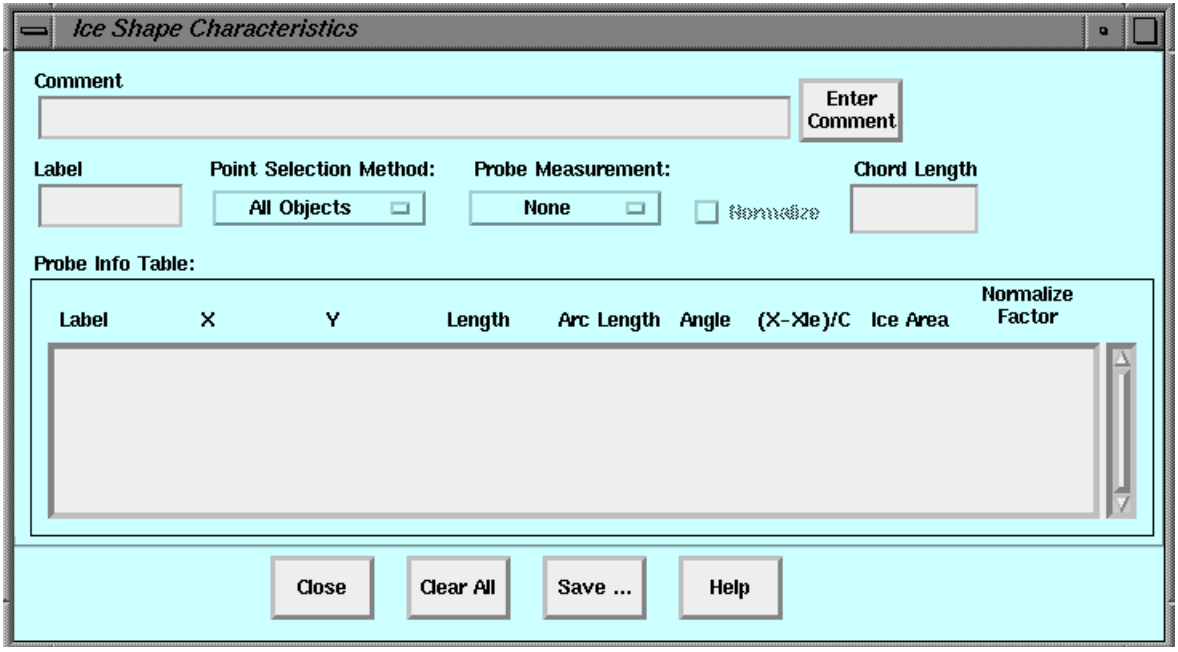

Figure 18. Ice Shape Characteristics Window

Parameters

Comment - Typing a string in this field has no effect until the Enter Comment button is pressed. At that time, the comment is entered on a separate line in the **Probe Info Table**.

Label - (up to 12 characters) Typing a string in this field just sets a value; no information is entered into the table until a measurement is made (see “controls” on page 33). At that time, this label, along with the measurement, is entered into the table. This field may be blank.

Point Selection Method - selects the method used to find points when making measurements; one of: *All Objects*, *Current Object*, *Reference Airfoil*, or *Arbitrary Point*.

All Objects - the closest point will be chosen by searching through all the objects.

Current Object - the closest point will be chosen from the currently-selected object only.

Reference Airfoil- the closest point on the reference airfoil will be chosen. In order to select this choice, a reference airfoil must have previously been set (menu selection: *Element-> Set Reference Airfoil*). If the reference airfoil is highlighted (menu selection: *View-> Highlight Reference Airfoil*), two additional points will be available to be chosen: the leading edge of the airfoil, or the center of the leading edge circle.

Arbitrary Point - the point chosen does not have to be on an object.

The user may change the point selection method at any time, even while in the middle of making measurements. So for example, when measuring length, one endpoint may be chosen using the Current Object method, and the second endpoint may be chosen using the Arbitrary Point method.

Probe Measurement - selects the probe type from the option menu; one of: *Location*, *Length*, *Arc Length*, *Angle*, *(X-Xle)/C*, *Ice Area* or *None*. This determines how the mouse will be used and what type of information will be entered into the **Probe Info Table**. Specific instructions for making each measurement appear in the "instructions" area in the Graphics Window mode.

Location - a single point should be selected; its (x,y) coordinates can be entered in the **Probe Info Table**.

Length - two points on the boundary of a single object should be selected; the distance between the two points can be entered in the **Probe Info Table**.

Arc Length - two points on the boundary of a single object should be selected; the length of the line segments along the boundary between the two points on the boundary can be entered in the **Probe Info Table**. The selection of the second point will be constrained to be on the same boundary as the first point. Also, since the points must be on a boundary, the *Arbitrary Point* selection method may not be used with this probe type.

Angle - two lines should be selected; the angle (in degrees) between the two lines can be entered in the **Probe Info Table**.

(X-Xle)/C - a single point should be selected; this value can be entered in the **Probe Info Table**. Here X = the x-coordinate of the selected point, Xle = the x-coordinate of the leading edge of

the reference airfoil, and C = the chord length of the reference airfoil.

Ice Area - this measurement can only be made if there is a reference airfoil and at least one other element. Two points on the boundary of a single element (which is not the reference airfoil) should be selected. Lines will be drawn to the closest point on the reference airfoil. The area bounded by those lines, the reference airfoil, and the other element will be computed. Normalizing the iced area is done by dividing by the area of the reference airfoil.

None - no probing type is active.

Normalize - selects whether or not normalization will be performed when calculating location, length, arc length, or ice area. The location, length, and arc length are normalized by dividing by the chord length. Ice area is normalized by dividing by the area of the reference airfoil. This normalization factor (i.e., the chord length or reference airfoil area) will be entered into the **Probe Info Table**. Because the chord length or airfoil area are needed for normalized measurements, a reference airfoil must be set in order to be able to choose this option.

Chord Length - displays the chord length of the reference airfoil when a reference airfoil has been set. However, this field will only be used in calculations when the **Normalize** box is checked.

Controls

Probe data are calculated and entered into the table by using the mouse. The particular Probe Measurement selected determines how the mouse is used. But in general, the left and middle mouse buttons are used to select points or endpoints of lines, and the measurement information will be displayed temporarily in the **Information** area of the Main Screen. Then when the right mouse button is pressed in the graphics window, the measurement information is entered into the **Probe Info Table**. The use of the mouse button clicks will be described in the **Instructions** area in the **Graphics Window Mode** section of the Main Screen.

Buttons

[Enter Comment] - Enters the text specified in the comment field into the Probe Table as a separate line.

[Close] - Closes the window

[Clear All] - Clears all entries in the **Probe Info Table**.

[Save] - Saves the data in the **Probe Info Table** to a file. A file selection window will open to allow the user to specify the output file.

[Help] - Displays help information for the ***Ice Shape Characteristics*** window.

Add Artificial Ice

The ***Add Artificial Ice*** window (Figure 19) allows the user to add computer-generated ice shapes to the surface of the current element. These modified surfaces can then be saved to be used later in studies of the effects that the various ice shapes have on the aerodynamic performance. Note: the reference airfoil should be set before opening this window (see page 22).

This window consists of

- **icons** representing the various ice shapes: forward-facing right triangle, backward-facing right triangle, generic triangle, rectangle, forward-facing quarter circle, backward-facing quarter circle, semi-circle, and trapezoid
- **four areas** for entering user-specified parameters: Location, Replication, Size, and Number of Points
- **buttons** for completing actions

The user selects the parametric ice shape to be added by pressing one of the eight icon push buttons. The background color of the icon that was selected will change from gray to blue to keep the user informed of their selected shape.

The user can modify the default values that the system assigned by typing in the text fields and pressing <Enter> or toggling between the radio buttons.

When an ice shape is selected, the modified surface with the ice shape added will be displayed temporarily as blue crosses overlaid on the graphics display. The changes do not become permanent until the **[OK]** or **[Apply]** button is pressed.

Figure 20 shows some of the settings that may be specified for different shapes.

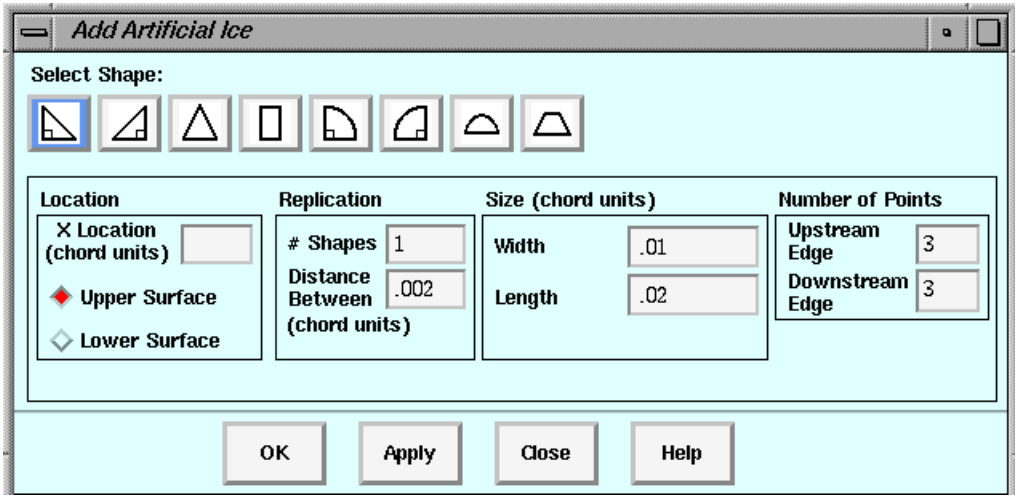

Figure 19. Add Artificial Ice Window

Select Shape

These icon push buttons select the parametric ice shape that will be added to the surface of the clean airfoil.

Location

The location is specified relative to the leading edge (left-most point) of the current element.

X location - The ice shape will be placed on the surface of the airfoil at this relative X location (specified in chord units). Right triangles and quarter-circles will be placed with their right angle at this location. All other shapes will be placed with the center of their base at this location. This value must be greater than 0 and less than 1.

Surface selection - Select the surface, either “Upper surface” or “Lower surface”, on which the ice shape(s) will be placed.

Replication

# of Shapes - If this value is 1, a single shape will be added; a number greater than one will add a train of shapes. If the number of shapes is too high to fit on the surface, a message will be displayed and no shapes will be added.

Distance between - When the number of shapes is greater than 1, this sets the distance between (the space between) individual shapes in the train.

Size (chord units)

Depending on the shape that is being added, different parameters can be set. All sizes are in chord units, except angle. The angle is measured in degrees relative to the normal to the airfoil at the shape location. A positive angle will tilt the shape upstream, while a negative angle will tilt downstream.

	generic triangle, rectangle	right triangle	trapezoid	semi-circle, quarter-circle
width	✓	✓		
top width			✓	
bottom width			✓	
length	✓	✓	✓	
angle	✓		✓	
radius				✓

Table 2. Size settings for various computer-generated shapes

Number of Points

Depending on the shape that is being added, the number of points on the ice shape boundaries will be specified differently.

	generic triangle, right triangle	rectangle, trapezoid	quarter-circle	semi-circle
upstream edge	✓			
downstream edge	✓			
x direction		✓		
y direction		✓	✓	
on arc			✓	✓

Table 3. Size settings for various computer-generated shapes

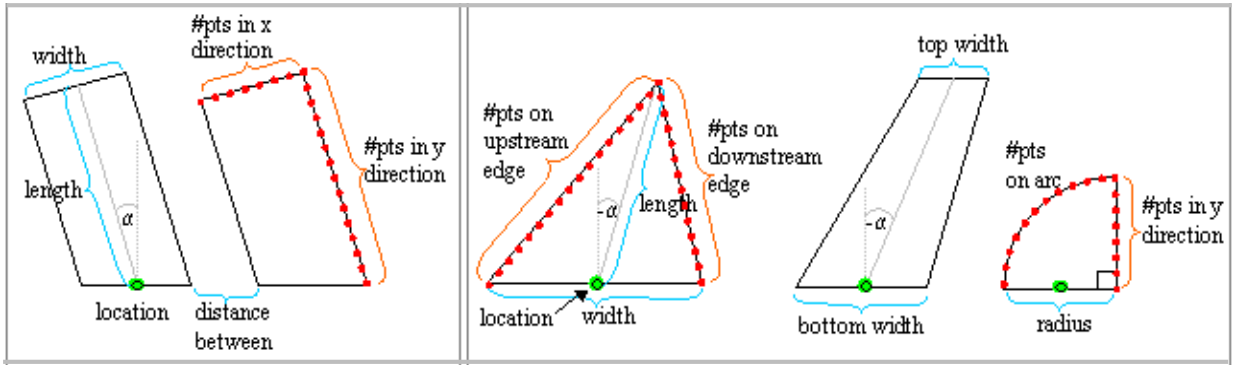

Figure 20. Some user-specified parameters for the various ice shapes; left-to-right: train of 2 rectangles, generic triangle, trapezoid, quarter-circle

Buttons:

[OK] - Applies changes and closes the window.

[Apply] - Permanently changes the geometry, by adding the ice shape geometry to the surface of the airfoil.

[Close] - Closes the window without Applying changes.

[Help] - Displays help information for the ***Add Artificial Ice*** window.

Move Element

The ***Move Element*** window allows the user to translate the current element and rotate it around a specified hinge point (Figure 21). All the user input values are relative to the original data. For example, if a rotation of 10 degrees is requested and applied, then later a rotation of 15 degrees is requested, the element will be rotated 15 degrees from its original position (as read in), not by 25 degrees.

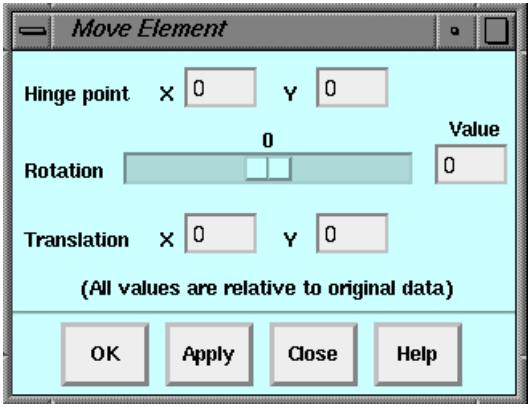

Figure 21. Move Element Window

Parameters

Hinge Point - X,Y location - the point about which the object will be rotated.

Rotation - the amount of rotation to apply; a value in the range [-180.0,180.0]. A positive value will rotate counter-clockwise and a negative value will rotate clockwise. Change this parameter by sliding the horizontal scroll bar or by typing the value in the text box and pressing <Enter>.

Translation - X,Y distance - the distance to translate the object in each direction from its original position.

When values are entered, the modified geometry is displayed temporarily as blue crosses overlaid on the graphics display. The changes do not become permanent until the OK or Apply button is pressed.

Buttons:

[OK] - Applies the changes and closes the window.

[Apply] - Permanently changes the geometry, by translating and/or rotating the current element around the user-specified hinge point.

[Close] - Closes the window without Applying changes.

[Help] - Displays help information for the ***Move Element*** window.

Discretize Subcurve

The ***Discretize Subcurve*** window allows the user to re-discretize the selected subcurve of the current object (Figure 22). The new discretized points are displayed temporarily as blue crosses overlaid on the graphics display. The changes do not become permanent until the OK or Apply button is pressed. This window consists of parameters and buttons.

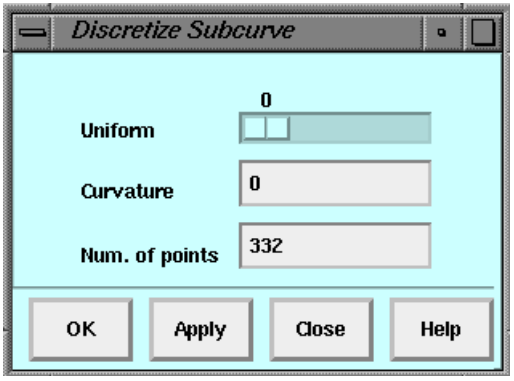

Figure 22. Discretize Subcurve Window

Parameters

Uniform - an integer value in the range [0,10]. A value of 0 makes no change to the original distribution, while a value of 10 distributes the points on the subcurve uniformly. Change this parameter by sliding the horizontal scroll bar.

Curvature - an integer value greater than or equal to zero. A greater number will cluster points more tightly in areas of high curvature. Note: There is no upper limit on this value, but if it is set too high, it may introduce twists in the subcurve. Change this parameter by typing an integer in the text box and pressing <Enter>.

Number of Points - the number of points in the discretized subcurve which is an integer value greater than or equal to two. Change this parameter by typing the number of desired points in the text box and pressing <Enter>.

Buttons

[OK] - Applies changes and closes the window.

[Apply] - Permanently changes the curve, replacing the old points with the newly discretized points.

[Close] - Closes the window without Applying changes.

[Help] - Displays help information for the ***Discretize Subcurve*** window.

Change Free Form Subcurve

The ***Change Free Form Subcurve*** window allows the user to change the shape of the selected subcurve by using control points (Figure 23). The new point locations are displayed temporarily as blue crosses overlaid on the graphics display. The changes do not become permanent until the OK or Apply button is pressed. This window consists of parameters, controls and buttons.

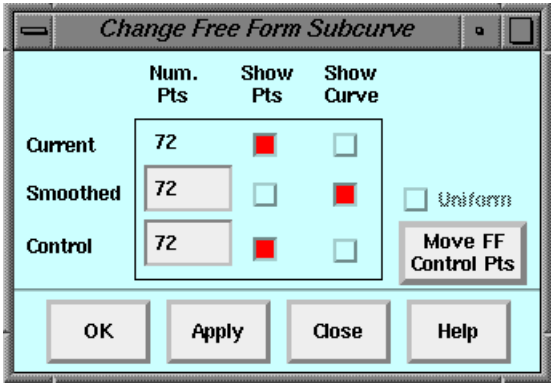

Figure 23. Change Free Form Subcurve Window

This feature enables the use of existing grid generators for CFD flow simulation by smoothing out often minute but complex variations of ice geometry while preserving prominent geometric features of ice. The level of smoothing is controlled by the number of "control" points. For the minimum smoothing, set the number of control points equal to the number of current points that defines the geometry. As the number of the "control" points is reduced, the ice shape becomes smoother.
Please note that the operation of the "Change Free Form Subcurve" is cumulative (unlike the "move element" feature). Caution is necessary when using this powerful feature. As one decreases the number of the control points, important ice features such as horn and feather tips can be compromised. To avoid this situation, users are advised to begin experimenting with the number of control points equal to the number of current points, then trying half the number of control points, and so on so that the level of smoothing is limited. If a user wants to smooth more while preserving the horn tips, then it is recommended that important points such as the horn tips are selected as the end points of subcurves since the subcurve end points do not change by this operation.

Parameters

Number of Smoothed Points - this text box contains the number of smoothed points to be calculated for the new curve; an integer value greater than or equal to 3 must be used. Note: entering a very large number (>50,000) may take a long time to process. Change this parameter by typing an integer in the text box and pressing <Enter>.

Number of Control Points - this text box contains the number of control points to be used to create the smoothed curve; an integer value greater than or equal to 3 must be used. The default is the lesser of 200 or the number of current points. The maximum value is equal to the number of current points. Change this parameter by typing an integer in the text box and pressing <Enter>.

Controls

Show check boxes - allows the user to select what will be shown in the graphics display while changing the free form subcurve. Points and/or curves for the current subcurve, the smoothed (modified) subcurve, and the control points can be displayed.

[Move FF Control Pts] - Sets the graphics mode to "Move FF Control Points". While in this mode, the user may move the control points, thereby changing the shape of the subcurve. Instructions for moving the control points will be displayed in the **Instructions** area in the **Graphics Window Mode** area of the main screen.

Uniform - this option is currently not available.

Buttons

[OK] - Applies changes and closes the window.

[Apply] - Permanently changes the curve, replacing the old points with the new points.

[Close] - Closes the window without Applying changes.

[Help] - Displays help information for the ***Change Free Form Subcurve*** window.

Tanh Redistribution

The ***Tanh Redistribution*** window allows the user to redistribute the points of the selected subcurve of the current object using a hyperbolic tangent stretching function (Figure 24). The new point locations are displayed temporarily as blue crosses overlaid on the graphics display. The changes do not become permanent until the OK or Apply button is pressed. This window consists of parameters and buttons.

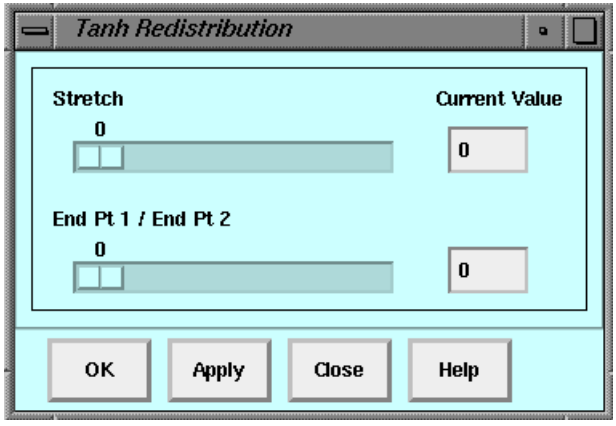

Figure 24. Tanh Redistribution Window

Parameters

Stretch - the amount of stretch to apply; an integer value in the range [0,100]. Change this parameter by sliding the horizontal scroll bar or by typing an integer in the text box and pressing <Enter>.

EndPt1/EndPt2 - indicates the endpoint toward which subcurve points will be clustered; an integer value in the range [0,100]. A value of 50 will stretch points equally towards both endpoints. Change this parameter by sliding the horizontal scroll bar or by typing an integer in the text box and pressing <Enter>.

Buttons

[OK] - Applies changes and closes the window.

[Apply] - Permanently changes the curve, replacing the old points with the redistributed points.

[Close] - Closes the window without Applying changes.

[Help] - Displays help information for the ***Tanh Redistribution*** window.

Online Help - UNIX

The SmaggIce help files are stored in HTML format. On UNIX systems, the on-line help is displayed using Netscape. If you have trouble displaying on-line help from SmaggIce, make sure Netscape is available on your workstation, and check to make sure the environmental variable `WEBBROWSER` was set correctly in the file `bin/runsmagg` in the smaggice directory. You may also view the help files independently of SmaggIce by pointing your browser to the file `help/index.html` in the smaggice directory.

Online Help - MS-Windows

The SmaggIce help files are stored in HTML format. On Windows systems, the on-line help is displayed using Internet Explorer. If you have trouble displaying on-line help from SmaggIce, make sure Internet Explorer is available on your PC, and check to make sure the environment variable `WEBBROWSER` was set correctly in the file `smaggrun.bat` in the smaggice directory. You may also view the help files independently of SmaggIce by pointing your browser to the file `Help/index.html` in the smaggice directory.

CHAPTER 5

Tutorial

This chapter will step you through the some general tasks in SmaggIce, and then present several scenarios: view modification, boundary modification, measuring ice shapes, adding artificial ice, and moving an element.

Note: If you have installed SmaggIce in a directory other than `$HOME/smaggice1.2`, modify all the pathnames in the tutorial accordingly.

General Tasks

This section will walk you through some general tasks that you will need to be able to do whenever you use SmaggIce.

Start Smaggice

Start up SmaggIce by executing the `runsmagg` script, which can be found under the bin subdirectory of smaggice. Enter it at the shell prompt, making sure to specify the full path name. For example:

```
$HOME/smaggice1.2/bin/runsmagg
```

Read geometry

You will read in a three-element airfoil. Select from the main menu: *File->Open*

In the ***File Open*** window,

- Select *Element Boundary* as the **File Type**.
- Read the file: `3elem.all.elt`
  from the directory `$HOME/smaggice1.2/geometry`.

- Close the window.

Select current object

SmaggIce performs operations on the current object. You may select the current object using one of these methods:

- Select from the main menu: *Boundary->Switch Object*. Do this several times to switch between the three objects.
- Use the hot key `<Ctrl>W`. You may do this several times in succession to cycle among objects.
- Type an object number directly into the **Object #** text box in the **Current Object Info** area of the main screen. Try entering 2 to switch to object number 2.

Notice that the selected object is displayed in red, and the non-selected objects are displayed in green. Also notice the information that is displayed in the **Current Object Info** area on the left portion of the main screen.

Get on-line help

On-line help is available and displayed through your web browser.

- To request general help from the main window, select from the main menu, *Help->Online Help...*
- As you start using other SmaggIce windows, you will see that specific help may be accessed by pressing the **[Help]** button at the bottom of each of those windows.

Clear all

At times you will want to clear all graphics and data, and return SmaggIce to its initial state.

- From the main menu, select: *Edit->Clear All.*

Exit

To exit SmaggIce,

- From the main menu, select: *File->Exit...*

You will be asked to verify your choice.

- Press **[Yes]** to exit.

Scenario 1 - View Modification (Geometry Transformation)

This section will explain how to perform geometry transformations to change the view you have of the geometry. You will be using the seven icons across the top of the screen to do this.

Startup

- Start SmaggIce (or select *Edit->Clear All*, if already running a session).
- Read the formatted element file: `3elem.all.elt` from the directory `$HOME/smaggice1.2/geometry`.

Graphics Mode transformations

The three icons on the top left of the graphics window (**[Translate]**, **[Scale]**, and **[Area Zoom]**) set the Graphics Window mode so that mouse movements in the graphics window will change the view. When you select any one of these, you will notice that the mouse cursor changes to indicate that you are in a special view manipulation mode.

- Press the **[Translate]** icon (notice that it turns blue, to indicate that the Translate mode is active), then follow the instructions in the lower left corner of the main screen to move the geometry around.
- Press the **[Scale]** icon. This will switch you to Scale mode and allow you to enlarge or reduce the image.
- Press **[Area Zoom]**. This allows you to draw a box around an area that will be enlarged to fill the screen.
- To exit any of these modes, click on the icon again or press the right mouse button. The icon will turn gray to indicate that the mode is not active, and the mouse cursor will return to its previous shape.

Immediate transformations

The four sets of icons on the top right of the graphics window (**[Full View]**, **[Zoom In]**, **[Zoom Out]**, and **Translate arrows**) immediately change your view of the geometry.

- Press **[Full View]** to reset the view to include all of the geometry.
- Press **[Zoom In]** or **[Zoom Out]** to scale the view up or down incrementally.
- Press one of the **Translate arrows** to move the geometry up, down, left, or right by the specified window fraction. You may also change the fraction by typing a new value in the center box of this control.

Scenario 2 - Boundary Modification

This section will show you how to select and modify subcurves.

Startup

- Start SmaggIce (or select *Edit->Clear All*, if already running a session).
- Read the element file: `clean+2ice.elt`
  from the directory `$HOME/smaggice1.2/geometry`.
- Notice that there are three objects: the full clean airfoil (a closed element) and two ice shapes (open elements). Make sure that object 1 is selected.

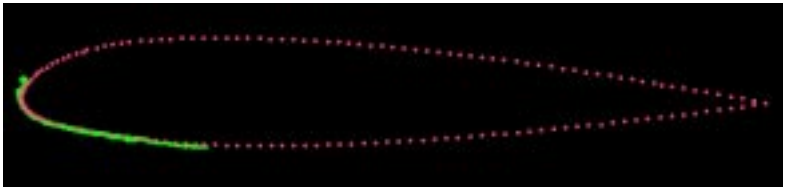

Figure 25. Geometry file: clean+2ice.elt; object 1 selected.

Select subcurve

Initially, the selected subcurve for an element is the entire curve. You will usually want to select only part of the curve to work with.

- From the main menu, select: *Boundary->Choose Subcurve*.
- Your cursor will change to indicate that you are in a special mode for selecting points. The instructions in the lower left corner of the screen will tell you how to select the endpoints of the subcurve. As you select the endpoints of the subcurve, notice how the information area changes. Also note that the points on the subcurve are displayed in red, while the points not on the subcurve are displayed in yellow.
- Select the upper surface of the airfoil as the current subcurve. This will be between point indices 1 and 83. You may find it easier to select specific points by using the mouse to click near the point, then using the arrow keys to set the exact point. The left and right arrow keys can be used to change the index of the most recently selected subcurve endpoint.
- To exit the Choose Subcurve mode, press the right mouse button.

Hyperbolic tangent redistribution

This allows you to redistribute the points in the selected subcurve. This tool will let you concentrate the distribution of points near the leading and/or trailing edge(s).

- From the main menu, select: *Boundary->Tanh Redistribution...*
- Notice that two sets of points are displayed: the current points as red dots and the modified temporary points as blue crosses.
- You may change the amount of stretch and how the stretching is distributed between the two endpoints by using the sliders in this window. You can also change a value by typing a number in the appropriate text entry area and pressing `<Enter>`. Set the **Stretch** value to `100` and the **EndPt1/EndPt2** value to `50`.
- If you would like to replace the current points with the modified temporary points, press **[Apply]**. To close the window without making the changes permanent, press **[Close]**. Pressing **[OK]** will apply the changes and close the window all at once.

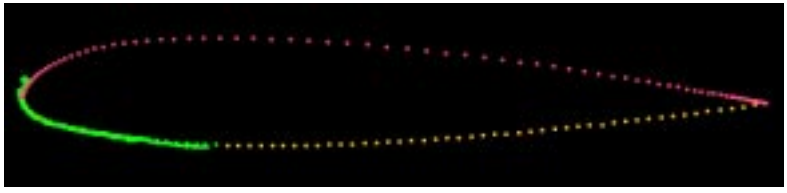

Figure 26. Redistributed points on upper surface of airfoil.

Discretize subcurve

This allows you to change the number of points in the subcurve and how they are distributed.

- Switch to object 2, and zoom in on the area at the leading edge of the airfoil (Figure 27). Select indices 1 and 56 as the endpoints of the subcurve by using the *Boundary->Choose Subcurve* menu selection.
- From the main menu, select: *Boundary->Discretize Subcurve...* If this menu selection is grayed out, it may be that you are still in the Choose Subcurve mode. (Follow the instructions area of the Graphics Window Mode, and click the right mouse button to exit that mode.)
- Again, the current points are displayed as red dots while the modified temporary points are displayed as blue crosses.
- To change the **Uniform** parameter, drag the slider. To evenly distribute the points, set this to the maximum value of `10`.
- Change the number of points in the subcurve to `100`, by typing that value in the text field and pressing `<Enter>`.

- Press **[Apply]** to make the changes permanent.
- You may want to concentrate the distribution of points near areas of high curvature. Set the **Uniform** parameter back to `0`, then type a value of `20` in the **Curvature** text field and press `<Enter>`.
- Make the changes permanent, or discard the changes the same way you did in the ***Tanh Redistribution*** window.

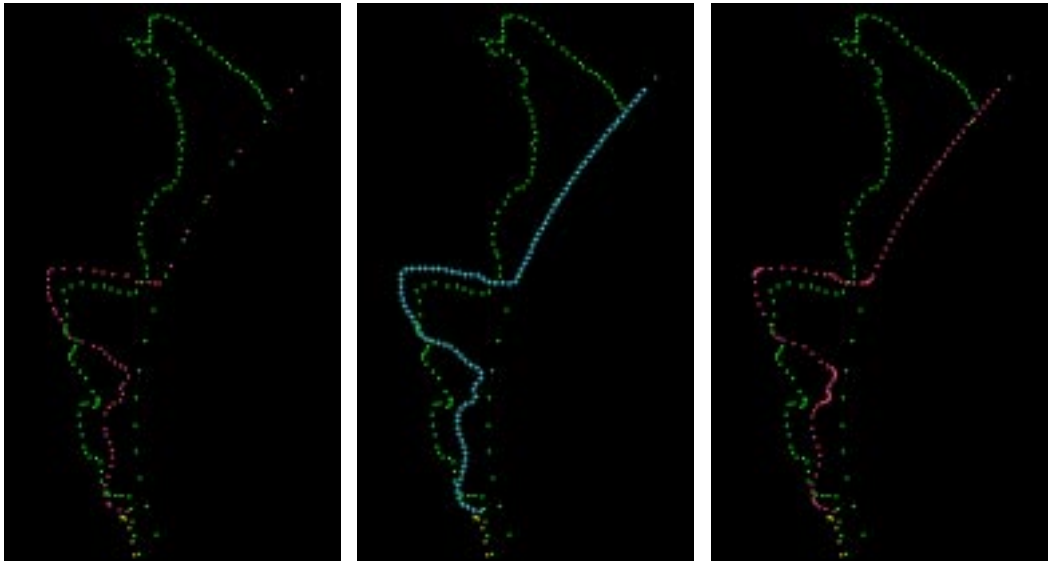

Figure 27. Left to right: original distribution; blue crosses show temporary curve uniformly discretized to 100 points; curve permanently changed to be discretized by curvature.

Change subcurve using free form method

This allows you to smooth the subcurve and modify the subcurve by moving control points. The control points, which define the shape, are moved one at a time using the mouse.

- Make sure the view is zoomed into the area at the front of the airfoil (Figure 28).
- Switch to object 3 and select indices 1 and 112 as the endpoints of the subcurve. (Remember to exit Choose Subcurve mode when you are done.)
- From the main menu, select:
  Boundary->Change Free Form Subcurve...
- The **check boxes** in this window will allow you to display the current points, the smoothed (modified) points, and the control points, as well as the lines connecting those points. Try turning these on and off.

- Increase the number of **Smoothed** points to `150` by typing that value in the text box and pressing `<Enter>`.
- Decrease the number of **Control** points to `40` by typing that value in the text box and pressing `<Enter>`. This has the effect of smoothing the subcurve.
- You can display points and/or curves for the current subcurve, the smoothed (modified) subcurve, and the control net. Click the check boxes (on/off) for the **Show Pts.** and **Show Curve** to change the display in the Graphics Window.
- You may also modify the curve by moving the control points. Press the **[Move FF Control Pts]** button. You are now in the Move FF Control Points mode. Follow the instructions to move control points. To exit this mode, press the right mouse button.
- Make the changes permanent, or discard the changes the same way you did in the ***Tanh Redistribution*** window.

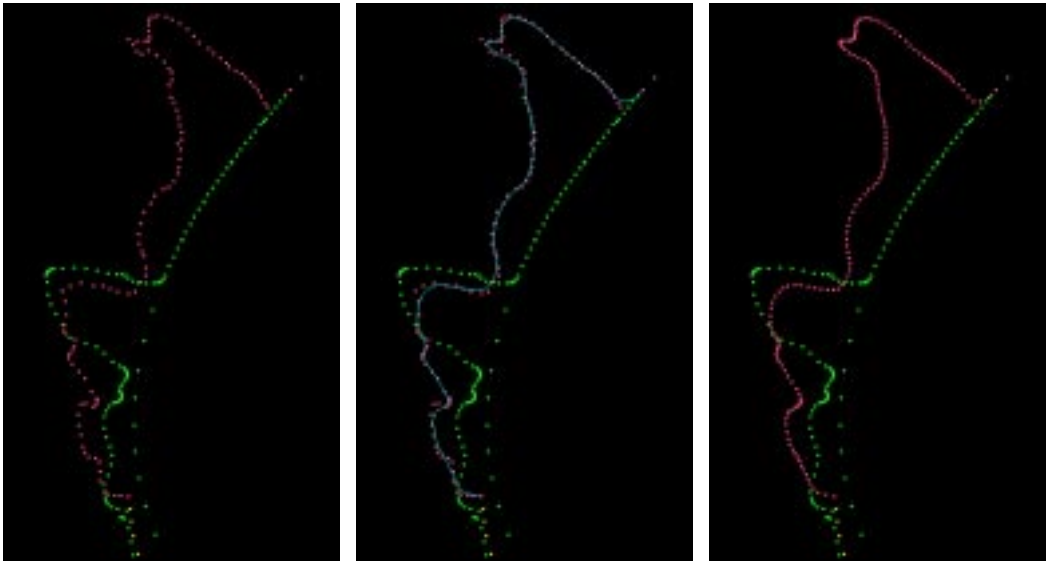

Figure 28. Left to right: original points; curve smoothed using 40 control points (control points not shown); new curve with 150 points.

Save modified geometry

After making these changes to the geometry, you may want to save the geometry to a new file.

- From the main menu, select: *File->Save As...*
- Under the **Save Object** option menu, select *All Elements*. Type the name of the new file in the **Selection** text box and click **[Save]**.

- You may want to select *Edit->Clear All* and then read in this new file to verify that the changes were saved.

Scenario 3 - Measuring Ice Shapes

This section will step you through the process of making measurements of ice shapes for ice shape characterization.

Startup

- Start SmaggIce (or select *Edit->Clear All*, if already running a session).
- Read the element file: `clean+3ice.scaled.elt`. This file contains 4 closed elements: a clean airfoil and three iced airfoils.
- Zoom in to the area at the leading edge of the airfoil.
- Select object 2 to be the current object.

Display point coordinates

You can display the coordinates of points in the current object. When you select a point, both its index and its (x,y) coordinates are displayed in the **Information** area of the main screen.

- From the main menu, select: *View->Display Point Coordinates*
- Follow the instructions in the lower left corner of the screen to select points and display their coordinates in the **Information** area. These coordinates are for immediate reference only. The following steps will show you how to keep a record of point locations, as well as other types of measurement information.
- To exit Display Point Coordinates mode, press the right mouse button.

Select reference airfoil

For some measurements, such as (X - Xle) / C, a clean airfoil must be identified as a reference, since the chord length C is determined from the reference airfoil. The chord length can also be used to normalize measurements such as length. In order to choose these calculations, you must first identify the clean airfoil so that the chord length can be determined.

- Select object 1 (the clean airfoil).
- From the main menu, select: *Element->Set Reference Airfoil*.

- You may want to highlight the clean airfoil by selecting from the main menu: *View->Highlight Reference Airfoil*. Notice that there are two additional points marked with purple crosses: the leading edge point, and the center of the leading edge circle. During measuring operations, you may select these points as you would others. (Figure 29)

Make measurements

- From the main menu, select: *Element->Ice Shape Characteristics*.
- Comments may be entered at any time into the **Probe Info Table**. Type "`Probing Tutorial`" in the comment text area, and press the `<Enter>` key or the [**Enter Comment]** button.

Location

Make a location measurement:

- Select *Location (X,Y)* from the **Probe Measurement** option menu. Follow the instructions in the **Instruction** area of the main window to select a point. Now select a different point. Notice how the probe information is displayed in the **Information** area of the main window. However, nothing is entered into the **Probe Info Table** until you press the right mouse button. Now enter the location into the **Probe Info Table** by pressing the right mouse button.

Length

You will next make a measurement of normalized length:

- Change the **Probe Measurement** to *Length*.
- You are currently able to choose points from all objects. Now change the **Point Selection Method** by selecting *Current Object* from that option menu. This will limit the points which may be selected to those on the current object only.
- Click on the **[Normalize]** check box to measure normalized length. This will normalize all measurements by dividing them by the chord length, which in this case is 8.000225.
- Type the string "`LE circ rad`" into the **Label** text field, indicating that this will be a measurement of the radius of the circle inscribed in the leading edge of the airfoil. This label will be entered into the **Probe Info Table** when you enter the measurement.

- Follow the instructions to select two endpoints: one being the leading edge of the airfoil, the other being the center of the leading edge circle (both marked in purple crosses). Enter the measurement into the **Probe Info Table**. Note that if the reference airfoil is not highlighted, you will not be able to select these two points.

Glyphs

You will have noticed that after measurements are entered into the **Probe Info Table**, symbols (or glyphs) such as points and lines are overlaid on the geometry to indicate where the measurements were made. You may want to turn off the display of these glyphs by selecting from the main menu: *View->Display Glyphs*.

Arc length

Arc length measures the sum of the lengths of the line segments along a boundary between two points on that boundary.

- Set the **Probe Measurement** to *Arc Length*, and turn **Normalize** off.
- Select the two endpoints: one being the leading edge of the reference airfoil, the other being the location where the ice attaches to the airfoil at the upper surface.
- Change the **Label** to "`ice limit`", and enter the measurement into the **Probe Info Table**.

Angle

To measure an angle, you will need to mark two lines between which the angle will be measured. Normalizing this measurement has no effect.

- Set the **Probe Measurement** to *Angle*.
- Following the instructions in the **Instruction** area, set the endpoints of the first line: the center of the leading edge circle and the leading edge point itself.
- For the second line, set the first endpoint to again be the center of the leading edge circle. For the second endpoint, set the **Point Selection Method** to *All Objects*, and select the tip of the uppermost ice horn.

- Change the **Label** to “upper horn”, and enter the measurement into the Probe Table.

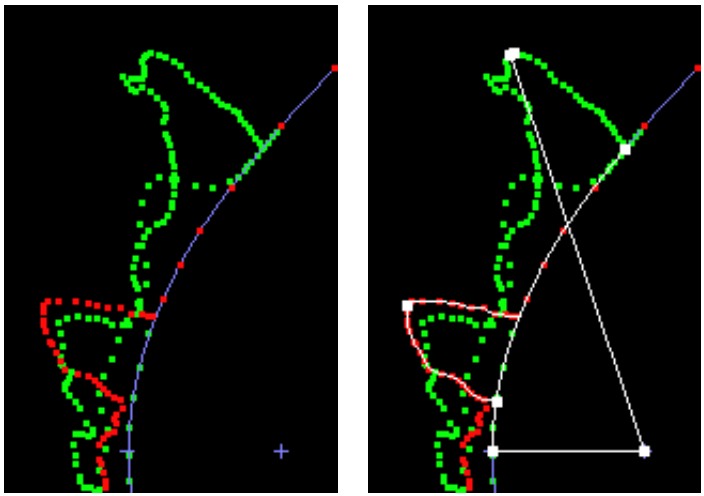

Figure 29. Left: highlighted reference airfoil with markers at leading edge and center of leading edge circle; Right: glyphs marking measurements of location, length, arc length, angle, and (X-Xle)/C.

(X-Xle)/C

This measurement calculates the value (X-Xle)/C, where X is the x-location of the point selected, Xle is the x-location of the leading edge, and C is the chord length of the reference airfoil.

- Set the **Probe Measurement** to *(X-Xle)/C*.
- Set the **Label** to “Ice Tip”, select the point on the tip of the uppermost ice horn, and enter the measurement into the Probe Table

Ice Area

Ice area measures an area between an ice shape and the reference airfoil. This measurement can only be made if there is a reference airfoil and at least one other element.

- Select object 4 to be the current object.
- Set the **Probe Measurement** to *Ice Area*.
- Set the **Point Selection Method** to *Current Object*, so that only point on the ice shape maybe chosen.

- Follow the instructions to select two endpoints on the ice shape. Lines will be drawn from the selected points to the closest point on the reference airfoil. The area bounded by those lines, the reference airfoil, and the Iced airfoil will be computed. If **Normalize** is on, that area is divided by the area of the reference airfoil.
- Type the string "`Ice area`" into the **Label** text field and enter the measurement into the **Probe Info Table** by clicking the right mouse button on the Graphics Window.

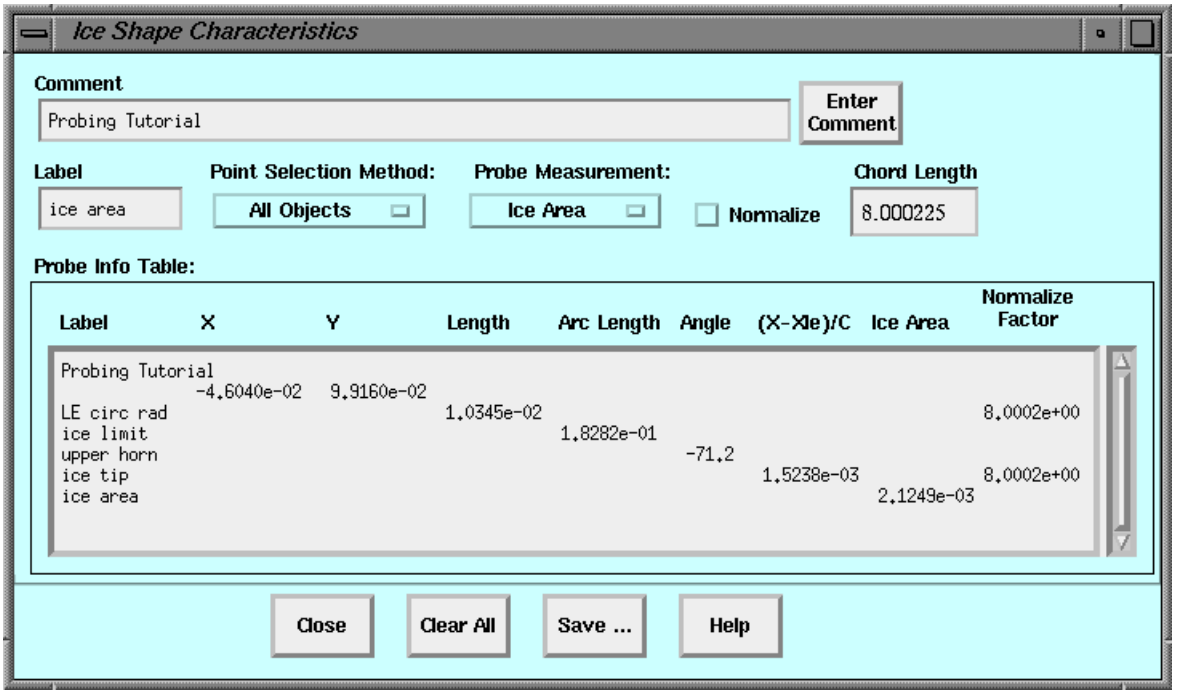

Figure 30. Ice Shape Characteristics window with entries in the Probe Info Table.

Save probe information

At this point, you may want to save the probe information to a file.

- In the ***Ice Shape Characteristics*** window, press the **[Save]** button. This will bring up a window which will allow you to save the **Probe Info Table** to a text file.

- You may also save a screen image of the geometry with the lines and points of your measurements displayed. If necessary, first turn glyph display back on by selecting *View->Display Glyphs* from the main menu, then select *File->Screen Save...*. You may choose to save the image as a TIFF, GIF, or PPM image file.
- To clear the **Probe Info Table** and all associated glyphs, press the **[Clear All]** button in the ***Ice Shape Characteristics*** window.

Scenario 4 - Add Artificial Ice Shape

This section will show you how to add computer-generated artificial ice shapes to an airfoil.

Startup

- Start SmaggIce (or select *Edit->Clear All*, if already running a session).
- Read the element file: `clean.elt`
  from the directory `$HOME/smaggice1.2/geometry`.
- Locations and sizes of artificial ice are specified in chord units. Set the reference airfoil first so that the chord length can be calculated. From the main menu select: *Element -> Set Reference Airfoil.*

Add Spoiler

Artificial ice is added to the current object. Since there is only one element read in, it is already set as the current object.

- From the main menu, select: *Element -> Add Artificial Ice.*
- Select the Rectangle push button.
- You will be asked to enter a value for the X-location. Type an X-location of `.02` and press `<Enter>`.

At this point you will see a small rectangle on the upper surface of the airfoil near the leading edge.

- Type a length of `.08`, an angle of `10`, and `8` as the number of points in the Y-direction. Notice that as you type parameters in the text area, no changes are displayed until you press `<Enter>`. Now press `<Enter>`. You will see a preview of the points on the spoiler displayed as blue crosses.

- To make these changes permanent, press the **[Apply]** push button.

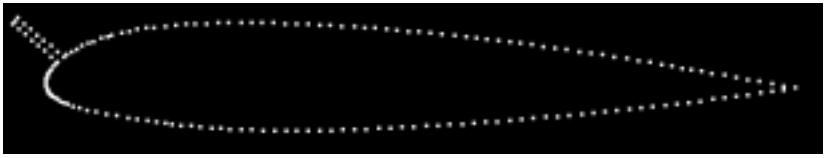

Figure 31. Airfoil with spoiler.

Add Train of Shapes

- Select the Semi-circle push button.
- Select the lower surface
- Enter the following values:
  X-location: `.1`
  # Shapes: `10`
  Distance Between: `.01`
  Radius: `.02`
  Press `<Enter>` to see a preview.
- Click the **[OK]** push button to make the changes permanent and close this window.

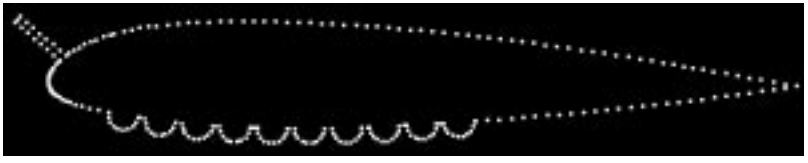

Figure 32. Airfoil with spoiler and train of ice shapes.

Scenario 5 - Move Element

This section will show you how to translate the current element and rotate it about a hinge point.

Startup

- Start SmaggIce (or select *Edit->Clear All*, if already running a session).
- Read the element file: `3elem.all.elt`
  from the directory `$HOME/smaggice1.2/geometry`.

- Notice that there are three closed objects: the slat, the main airfoil and the flap. Make sure that object 1 is selected, which is the slat.

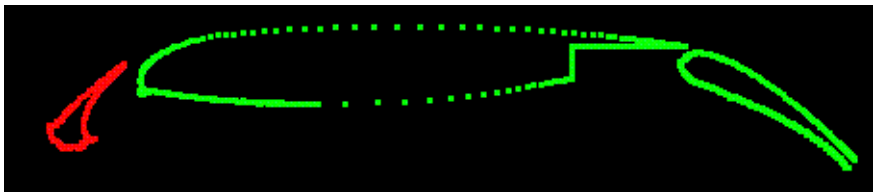

Figure 33. Geometry file: 3elem.all.elt; object 1 selected.

Move Element

- From the main menu, select: *Element -> Move Element*. For the rotation of the slat, use the default hinge point location of `(0,0)`. Note, for other geometries, you may need to specify a hinge point location other than (0,0). For instance, for the rotation of the flap, try `(0.87, 0.00146)`.
- Change the **Rotation** parameter: drag the slider to the left to `-20` or enter the value in the adjacent text field and press `<Enter>`. Notice the slat is rotated around the hinge point location `(0,0)`. Translate the object by entering a value of `.05` for X-translation and `.05` for Y-translation. Press `<Enter>`.
- The Graphics Window displays the original current element (red dots) and a preview of the translated/rotated object (blue crosses).

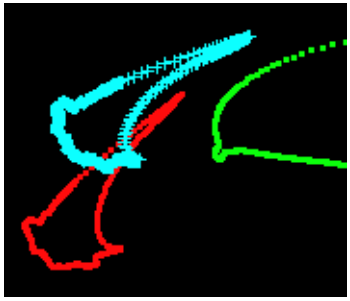

Figure 34. Rotation and translation of the slat

- Press the **[Apply]** push button to make the changes permanent. The window will stay open to allow you to make further changes. When you are finished press the **[Close]** push button. If you want to make the changes permanent and close the window in one step, press the **[OK]** button.

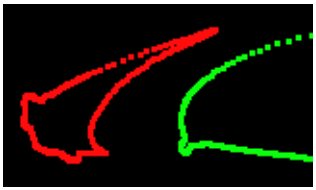

Figure 35. Permanent changes of the slat

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